

A new species of *Brachyorrhos* from Seram, Indonesia and notes on fangless homalopsids (Squamata, Serpentes)

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Abstract

Homalopsid snakes are monophyletic and contain two major subclades: a fangless clade and rear-fanged clade. They are distributed in South Asia, Australasia, and the Western Pacific. The fangless clade is restricted to the eastern Indonesian Archipelago and the island of Sumatra and is poorly known in terms of its natural history. Molecular data support the eastern Indonesian fangless endemic genus *Brachyorrhos* as the sister to the rear-fang clade. Here we recognize the identity of the *Brachyorrhos* population from the island of Morotai as *B. wallacei* and describe a new species of dwarf *Brachyorrhos* from the island of Seram, Maluku, Indonesia. The new species can be distinguished from all congeners by a lower number of ventral scales, the presence of a preocular scale and a loreal scale, as well as its exceptionally diminutive size. The new species is a candidate for the smallest alethinophidian snake. The three fangless genera, *Brachyorrhos*, *Calamophis*, and *Karnsophis*, have been suggested to form a clade of homalopsid snakes restricted to the Indonesian Archipelago, and we discuss their biogeography.

Keywords: biogeography, *Calamophis*, Homalopsidae, *Karnsophis*, small snakes

Introduction

Snakes in numerous lineages show specializations for fossoriality. Morphological trends associated with burrowing include the loss or fusion of cephalic scales, a reduction in the number of dorsal scale rows, modifications of the premaxillary bone, and abbreviation of the tail (Savitzky 1983). Fossorial snakes also have constraints on the head's width because it influences the snake's ability to penetrate the substrate and exposes cranial bones to the physical stress of burrowing. Also associated with fossorial specializations are small size and a reduced number of ventral scales (Inger & Marx 1965). An analysis of snakes from biogeographic realms found 27.8 % in the Oriental region were fossorial and suggests that fossorial snakes of all lineages are likely to be among the most derived (Rabb & Marx 1973).

The eastern Indonesian homalopsid snake genus *Brachyorrhos* Kuhl in Schlegel, 1826 is endemic to the

Maluku Islands of eastern Indonesia and represents a fangless, vermivorous clade of otherwise mostly rear-fanged, piscivorous snakes.

In a review of the genus *Brachyorrhos*, Murphy *et al.* (2012) found *B. albus* (Linnaeus, 1758) occurs on Seram, Ambon, and nearby satellite islands in the Seram Island group. They removed *Rabdion gastrotaenia* Bleeker, 1860 from the synonymy of *Brachyorrhos albus* (on Buru Island) and *Atractocephalus raffrayi* Sauvage, 1878 (1879) was resurrected for the *Brachyorrhos* species (on Ternate Island); they also described a new species from Halmahera, *B. wallacei* Murphy, Mumpuni, de Lang, Gower, & Sanders, 2012. Additionally, they removed *Calamophis* Meyer, 1874 from the synonymy of *Brachyorrhos*. Figure 1 illustrates the distribution of the three fangless genera, two from West Papua, and one from Sumatra, *Karnsophis siantaris* Murphy & Voris, 2013. Together, these three genera likely form a fangless clade of basal homalopsids (Murphy & Voris 2014). The genera *Karnsophis* and *Calamophis* were tentatively assigned to the Homalopsidae based upon their morphological similarities to *Brachyorrhos*. To date, only *Brachyorrhos* has been included in phylogenetic analyses using molecular data.

Here we describe a novel species of *Brachyorrhos* and discuss the biogeography of the fangless homalopsids. *Brachyorrhos* contains small (< 74 cm total length) snakes with 19 scale rows at the mid and posterior body and relatively short tails (7.5–18% of the SVL). Most specimens have the prefrontal,

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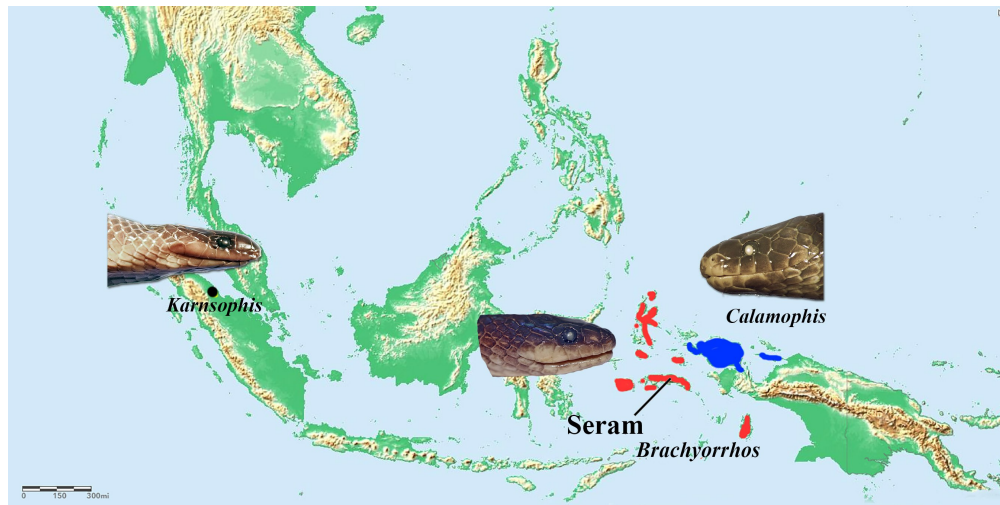


Figure 1. Distribution of the fangless homalopsids. *Karnsophis siantaris* (upper left), *Brachyorrhos albus* (center), *Calamophis sharonbrooksae* (right).

loreal, and preocular fused, some have a single postocular and this is diagnostic in at least two taxa. Although some species show a pattern of head and nape markings (these are most often present in neonates and juveniles), and a mid-ventral stripe, most specimens have a uniform brown to brown-black dorsum and a yellow or cream venter. All *Brachyorrhos* have a divided internasal, and none show a posterior reduction in dorsal scales anterior to the cloacal plate.

The goals of this paper are to resolve two issues that remained after the publication of Murphy *et al.* (2012). First, we describe a novel species of *Brachyorrhos* from the island of Seram based on a single specimen collected in 1909. The specimen is morphologically divergent from other *Brachyorrhos* in its low ventral count, the presence of a loreal, and its exceptionally small size. Secondly, a specimen of *Brachyorrhos* from the island of Morotai, is reported here for the first time. Morotai is one of the northernmost islands in the Halmahera group of the Malukus and is about 470 km southeast of Mindanao in the Philippines. No snakes in the genus *Brachyorrhos* have been previously described from Morotai.

Materials and Methods

Museum specimens of *Brachyorrhos* were examined, and external morphological data were collected for 64 museum specimens (Appendix 1). Measurements of body and tail lengths were taken to the nearest 1 mm with a meter stick; ventral scales were counted following Dowling (1951). The terminal scute was not included in the number of subcaudals. Dorsal scale row counts were made about ten ventrals behind the head, at mid-body, and about ten ventrals anterior to the vent. Scale

nomenclature follows Lillywhite (2008). Values for paired head scales and subcaudals are given in left/right order. A principal component analysis (PCA) was done with Excel (2019, v16) with Xlstats (2020.1). The PCA used 33 *Brachyorrhos* specimens representing all known species of the genus including the new species described here. Data collected included: ventral scale counts, subcaudal scale counts, preocular presence or absence, number of upper labials, tallest upper labial, number of lower labials, presence, or absence of a loreal. The variables, eigenvalues and factor correlations are given in Appendix 2.

Abbreviations are: MY - millions of years; MYA - millions of years ago; N - number of specimens; \bar{x} - mean value; SVL - snout vent length; SD - standard deviation; PLP - prefrontal-loreal-preocular scales fused together.

Results

Since the publication of Murphy *et al.* (2012) we had the opportunity to examine additional specimens and consider some unresolved problems posed by a specimen examined during the review of *Brachyorrhos*. The results are divided into two sections, the new species of *Brachyorrhos* from Seram, and the identity of the specimen from Morotai. While examining specimens of *Brachyorrhos* at the Natural History Museum (NHM), formerly the BMNH, one of us (JCM) collected data on a small *Brachyorrhos* (BMNH 1910.4.26.60) that Samuel McDowell had previously examined. The museum's catalog contained the following paragraph in the form of a hand-written note concerning the specimen collected in 1909 on Seram by Wilfred Stalker.

This snake has ca. 40 ventrals too few, lacks any trace of a tracheal lung, has no bar of bone ventral to nerve V2 to define a foramen for that nerve in the palatine, and has mature ovarian eggs although with a colour pattern suggestive of a juvenile. It has posterior hypapophyses and seems referable to *Brachyorrhos*. But Ceram *B. albus* are similar to your Ternate specimens as least to judge from AMNH specimens. I have seen one specimen approaching this, a male from the Vogelkop (Bishop Mus.) and I suspect this specimen is a Ceram record for *Brachyorrhos jobiensis*.

Sam McDowell, 18 July 1978

Examination suggested that it was a *Brachyorrhos*. It has 19 dorsal scale rows that were not reduced posteriorly, a head scale arrangement mostly consistent with *Brachyorrhos*, and a color pattern similar to that seen in juvenile *Brachyorrhos*. The specimen shares two postoculars; one preocular; a fused loreal and prefrontal; upper labials 7/6, the fourth bordering the orbit; four lower labials contacting the chin shields; two internasals; and 19 dorsal scale rows that are not reduced posteriorly with most other species of *Brachyorrhos*. McDowell (1987) associated the small size and the low ventral scale count with *Calamophis jobiensis* (Meyer, 1874) which prompted him to suggest the specimen was *Brachyorrhos jobiensis* Meyer, 1874. *Calamophis* had been placed in the synonymy of *Brachyorrhos* by Peters & Doria (1878). Later, McDowell (1987) wrote that *Brachyorrhos* would be a homalopsid if they had fangs. A molecular study (Murphy *et al.* 2011) later confirmed *Brachyorrhos* was in the family Homalopsidae and the sister to all other homalopsid snakes.

Little is known about the collector of BMNH 1910.4.26.60, British naturalist and bird collector Wilfred Stalker. Stalker made a trip to central Seram in 1909 where he assembled a "remarkable zoological collection." (Anon. 1910:436) BMNH 1910.4.26.60 was part of that collection. Stalker was preparing for the British Ornithologists' Union's collecting trip to New Guinea and he met the other members of the expedition in Amboina on January 1, 1910. Eight days later he drowned (Anon. 1910; Wollaston 1912). Stalker collected many bird specimens that later became holotypes (LeCroy, 2003; Lily, 2008) evidence that his collections were made in localities not previously investigated by zoologists.

We included BMNH1910.4.26.60 in a principal component analysis (Fig. 2 and Appendix 2) and found it similar to other *Brachyorrhos* in morphospace but it stands alone because of its distinctive morphology (a preocular, a loreal, and a low ventral count). *Brachyorrhos* are the only homalopsid snakes known to have bilobed nasal scales separated by the rostral; a divided internasal positioned

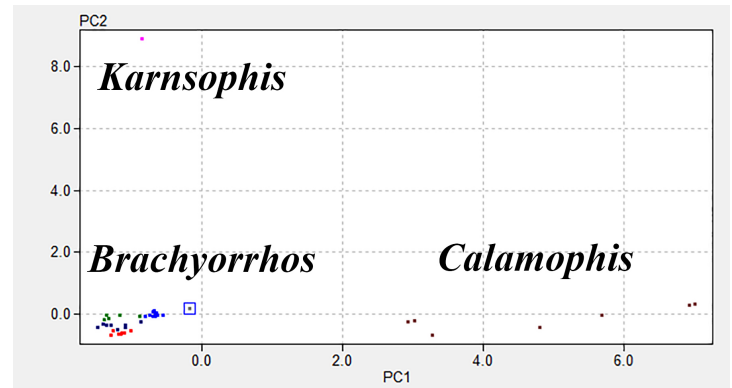


Figure 2. Results of a principal component analysis. Details in Appendix 2.

posterior and dorsal to the nasals. *Brachyorrhos* is distinguished from *Calamophis* by the lack of a reduction in dorsal scale rows (*Brachyorrhos* has 19-19-19, *Calamophis* has 19-19-17). *Brachyorrhos* has dorsal scales that are ovate, slightly imbricate or juxtaposed compared to the distinct imbricate dorsal scales in *Calamophis*, *Brachyorrhos* has a divided nasal scale, and a tail that lacks a constriction at its base and tapers gradually to the tip. Given the morphological evidence we describe BMNH 1910.4.26.60 below as the fifth species in the genus *Brachyorrhos*.

Taxonomic Results

Brachyorrhos pygmaeus species nova

Figure 3

Holotype: BMNH1910.4.26.60, a mature female from Seram Island, Maluku, Indonesia collected in 1909 by Wilfred Stalker.

Type Locality: Seram Island.

Diagnosis. A *Brachyorrhos* with a rounded snout, a loreal scale; one preocular scale; upper labials six or seven, the fourth upper labial bordering the orbit; the second and third upper labials contact loreal; six lower labials; 143 ventral scales; 22 subcaudal scales; the tail is 11.5% of the SVL.

Description of Holotype: a mature female with a total length of 128 mm; tail 13 mm. Rostral slightly visible from above; snout rounded; nasals bilobed with posterior lobe penetrating the seam between the prefrontal and second upper labial, and separated by two internasals. Frontal pentagonal, shorter than parietals; two prefrontals contact loreals on each side; preocular single; postoculars two; primary temporal single; seven upper labials on the left and six on the right, loreal contacts second and third, the

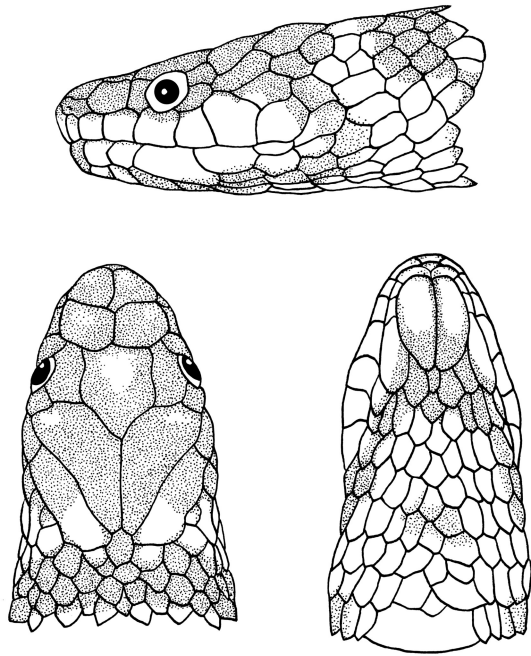


Figure 3. Holotype of *Brachyorrhos pygmaeus* BMNH1910.4.26.60. Drawings by Nathalie Aall.

fourth enters the orbit, the sixth is the tallest; six lower labials, first four contact the chin shields, the fourth is the longest; eight gulars. Dorsal scales smooth, ovate, and in 20 rows on the anterior body, 19 rows at mid-body and posterior body; ventrals 143, cloacal plate divided, subcaudals 22 and divided.

Coloration in alcohol: Crown red-brown, pale spot on frontal, transverse cream nape band immediately behind parietal scales and interrupted at the parietals by red-brown pigment. Scales above labials red-brown, upper, and lower labials cream except for some red-brown pigmentation on the upper labials under and anterior to the eye. The red-brown pigment extends past the rictus onto the gulars and posterior edges of the chin shields. Isolated spots of red-brown pigment on the posterior gulars, and anterior ventrals. On the right side, a lateral cream stipe on anterior body scale rows 6–8 starting about the third ventral and continuing to the seventh ventral, on the left side the stripe is much shorter. The ventral surface is mostly a uniform cream with some ventrals having red-brown spots on the edge. The first dorsal scale row is cream; the second row has a central cream spot on each scale edged in red-brown pigment; the same pattern is present on the third row with a much less pale pigment. Dorsal scales above row three are mostly a uniform

red brown. The ventral surface of the tail is a uniform cream with a mid-line zig-zag stripe that follows the inner edges of the subcaudal scales.

Table 1 compares this species to other members of the genus.

Etymology: The epithet is derived from the small size of this snake.

Material Examined – Seram: BMNH1910.4.26.60

The *Brachyorrhos* population on Morotai Island

A specimen (USNM 159973) collected on the southeast corner of Morotai Island, on 29 September 1944 has a total length of 730 mm, a tail of 71 mm, 173 ventral scales, and 39 subcaudal scales. Rostral and nasal scales visible from above; internasal divided; prefrontal fused with loreal and preocular (a PLP shield); upper labials six; PLP shield contacts upper labials 2-3; the third upper labial enters the orbit, the fifth upper labial is the tallest; postoculars two, the bottom scale extends under eye; two elongated, very narrow temporals contact postoculars on right, only one of two temporals makes contact on the left; eye diameter less than the eye-mouth distance. This specimen agrees well with *Brachyorrhos wallacei* from the island of Halmahera nearby located southwest of Morotai, both belonging to North Maluku province. The two islands are separated by an open water channel about 19 km wide and a trench that reaches a depth of approximately 260 m.

Discussion

Fangless homalopsids comprise three genera (*Brachyorrhos*, *Calamophis*, and *Karnsophis*) of ten species restricted to Indonesia. All are less than 74 cm in total length, some are terrestrial, others fossorial and possibly semi-aquatic but all can be regarded as having poorly known life histories; details of microhabitats, diets, reproduction, daily activity all remain unknown. Here we describe the smallest known homalopsid, a fangless species from the island of Seram in Maluku province. We note that its placement in the genus *Brachyorrhos* is based entirely on morphology, and we cannot rule out the possibility that once molecular data are available it will be assigned to a different lineage.

Table 1 suggests that *Brachyorrhos pygmaeus* and *B. albus* share a remarkably similar external morphology, differing in the number of ventrals, a preocular, a loreal, and snout shape. For a perspective on the relationship on the difference in size we measured several near-term embryos of *Brachyorrhos albus*, which ranged from 136 to 147 mm in total length. Based on

Table 1. Summary of some diagnostic characters used to distinguish between the five species of *Brachyorrhos*.

	<i>albus</i> (n=20)	<i>gastrotaenius</i> (n=9)	<i>raffrayi</i> (n=17)	<i>wallacei</i> (n=10)	<i>pygmaeus</i> (n=1)
Distribution	Ambon, Seram, Bisa	Buru	Ternate	Halmahera, Morotai	Seram
Preocular	present	absent	absent (65%)	both	present
Loreal	absent	absent	absent	absent	present
Number of upper labials	7	6	6	7 (rarely 6)	7/6
Upper labial in orbit	4 (rarely 3+4)	4	3	3 or 4	4
Tallest upper labial	6	5	3	6 (rarely 5)	6
Ventrals males	159–173	177–193	169–177	169–182	nd
Ventrals females	171–178	187–195	176–182	170–174	143
Subcaudals males	26–36	34–37	30–37	33–42	nd
Subcaudals females	23–27	18–29	27–28	26–31	22
Snout	pointed	pointed	very pointed	pointed	rounded
Mid-ventral stripe	absent	usually present	absent	absent	absent

McDowell's notation accompanying BMNH 1910.4.26.60, *B. pygmaeus* contained mature ovarian eggs and is therefore sexually mature at a total length of 128 mm, 6–9 mm less than a *B. albus* embryo. The exceptionally small size of *Brachyorrhos pygmaeus* makes it a candidate for the world's smallest alethinophidian snake.

The smallest snakes are in the scolecophidian family Leptotyphlopidae and the smallest known snake is the scolecophidian, *Tetracheilostoma carlae* (Hedges, 2008) from Barbados (West Indies). The largest known adult is 104 mm. Six leptotyphlopidae species have maximum lengths that are less than 105 mm; four are known only from their holotypes (Hedges 2008). However, as noted by Hedges (2008), as species become better known and the number of specimens increases, the maximum size also increases.

Within the alethinophidian snakes, a few species in several lineages approach the diminutive size seen in the scolecophidians. The highly specialized shield-tailed snakes (Uropletididae) include *Uropeltis petersi* (Beddome, 1878), a species known to reach 190 mm in total length, but it is known from only six specimens (Smith 1943; Pyron *et al.* 2016). There are many small, fossorial colubroid snakes in the 200–300 mm

total length range. Within the Colubroidea, Inger & Marx (1965) listed 41 species of dwarf reed snakes in the genus *Calamaria* (Colubridae). Of those, only five species did not exceed 200 mm; and all were represented by less than three individuals. Recently, Koch *et al.* (2018) described *Calamaria banggaiensis* Koch, Arida, McGuire, Iskandar & Böhme, 2009 that has a total length of 199 mm. There are several exceptionally small black-headed snakes in the genus *Tantilla*. Savage (2002) reports *Tantilla vermiformis* (Hallowell, 1861) reaches a maximum length of 157 mm, and it is well represented in collections. The Australian elapid, *Simoselaps anomalus* (Sternfeld, 1919) reaches a maximum of 210 mm total length, and *S. minimus* (Worrell, 1960) reaches 219 mm (Clarke & How 1995). In the family Dipsadidae, the Middle American *Geophis bellus* Myers, 2003 is 210 mm in total length (Myers 2003). Passos *et al.* (2009a) described *Atractus multidentatus* Passos, Rivas Fuenmayor & Barrio-Amorós, 2009 based upon a single adult female that was 172 mm in total length from Venezuela's Cordillera de Mérida; later, Passos *et al.* (2009b) described *Atractus avernus* Passos, Chiesse, Torres-Carvajal & Savage, 2009 based upon a single specimen that was 177 mm in total length. Both species may eventually be found to exceed 200 mm

in overall length. The Malagasy *Pseudoxyrhopus kely* Raxworthy & Nussbaum, 1994 (Lamprophiidae) has a maximum length of 217 mm (Glaw & Vences 2007). The smallest viperid is *Bitis schneideri* (Boettger, 1886) at 260 mm maximum length (Mallow *et al.* 2003). Thus, the smallest, best documented alethinophidian snake is likely *Tantilla vermiformis* at 157 mm.

The Homalopsidae now includes ten fangless species plus 45 rear-fanged species that are mostly semi-aquatic snakes ranging from the Indus River in Pakistan to the northwest coast of Australia and Micronesia (Vyas *et al.* 2013; Murphy & Voris 2013; Quah *et al.* 2017). Most of the species (37 of 45) occur in South and Southeast Asia, including the larger islands of the Sunda Shelf (Murphy & Voris 2013; Quah *et al.* 2017). Of the ten fangless species, only one has been found on the Sunda Shelf (*Karnsophis siantaris* on Sumatra). These numbers can be expected to change as more species are described and some current taxa are synonymized.

The remaining nine species are restricted to the eastern part of Wallacea, (e.g. North and South Moluccas, *Brachyorrhos*, 5 species) and on the Sahul Shelf in the Bird's Head region of Papua (*Calamophis*, 4 species) (Murphy 2012, Murphy *et al.* 2012). Thus, both the fanged and fangless homalopsids have distributions that extend from South and Southeast Asia, across Wallacea to New Guinea, Australia, and Micronesia. Extant rear-fanged homalopsids were thought to share a common ancestor between 30 and 15 MYA (Alfaro *et al.* 2008).

However more recent works push homalopsids to older dates of divergence, with Burbrink *et al.* (2020) suggesting the families Pareidae, Viperidae, and Homalopsidae diverged within the Paleogene. Alfaro *et al.* (2008) strongly suggest that the fanged homalopsids date to at least the early Miocene or mid to late Oligocene, i.e., 30 to 20 MYA. The results obtained by Alfaro *et al.* (2008) are not necessarily in opposition to the earlier dates obtained by Harrington & Reeder (2017) and Burbrink *et al.* (2020). Tissue from *Brachyorrhos* (the fangless clade) was not available until 2011 (Murphy *et al.* 2011). More recently Bernstein *et al.* (2021) obtained a divergence date between the fangless and fanged clade of 43.31 MYA \pm 1.63 MY.

The early Miocene to mid and late Oligocene (20-30 MYA) corresponds closely to when the Australian plate including New Guinea, the Bird's Head, and some fragments of the Maluku (=Moluccas) had moved north to lie adjacent to the southeast edge of the Sunda Shelf (Hall 1996, 2002). Other fragments such as Halmahera were moving west and south towards their present-day location. This scenario suggests homalopsids could have moved from the Sunda Shelf to the

Sahul Shelf in the Oligocene or early Miocene and that the early fangless homalopsids spread from South Asia via the southern edge of the Sunda Shelf to fragments of Wallacea and land components on the Sahul Shelf (Hall 2002, figs. 20, 21; Oliver *et al.* 2018, fig 2). This scenario also suggests that fangless and semiaquatic rear-fanged homalopsids have spread east from Southeast Asia into Wallacea and Australia in multiple waves during the Paleogene and into the Miocene (Alfaro *et al.* 2008, Murphy 2011, Bernstein *et al.* 2021).

The movement of both homalopsid clades (rear-fanged and fangless) from Southeast Asia to the Sahul Shelf in the Oligocene or Miocene seems probable, but the family is older than previously thought – with diversification in the Paleogene (Burbrink *et al.* 2020). Although alternative scenarios have not yet been forthcoming based on the revised older dates.

Morphology has been used for centuries to determine relationships of organisms and with the advent of molecular techniques those relationships could be better defined. *Brachyorrhos* is the only one of three fangless homalopsids represented in phylogenetic studies with molecular data. The other two genera *Calamophis* and *Karnsophis* remain poorly known. With advanced techniques of recovering DNA sequences from specimens fixed in formalin, the relationships of these snakes may soon be illuminated using DNA extracted from older, traditional museum specimens (Ruane & Austin 2017).

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Appendix 1. Material examined. *Brachyorrhos albus* - Ambon: Waai- –FMNH 134322–24, 142332, 142145–46; MZB 1524A–B No specific locality–MSNG30192a; Seram: Honitoe –FMNH 109949, 119654; BMNH 442222, 6312425; Saunulu –MZB2364; RMNH 576; ZMA 10494(2); ZMA10104(2). Pulau Bisa – MZB2609. *Brachyorrhos gastrotaenius* “Ambonia” (probably in error see comments) –BMNH6312425; Buru – Fakal: ZMA13.044(3); Rana – ZMA12.844(3). *Brachyorrhos pygmaeus* - Seram: BMNH1910.4.26.60. *Brachyorrhos raffrayi* - Ternate: BMNH82.11.25.14, and 48.1.31.10; MNHN 5174, 5782 and 1991.1657; MSNG30222a–f, 54459-62; MZB T128, T099. *Brachyorrhos wallacei* – Halmahera: Jailolo MZB-BJE01059 MZB-BJE01054, MZB-BJE01058; Kampung PasirPatih–USNM 237145–150; Sidangoli– MZB2111; Weda Bay Mines– MZB-WD0128.

Appendix 2. Details of PCA.

	PC	% Variation	Total Variation
1	T/SVL	44.03	44.03
2	ventrals	17.15	61.18
3	subcaudals	12.81	74.00
4	DSR	10.31	83.30
5	postocular	6.34	90.64
6	upper labials	4.85	95.49
7	upper labials in orbit	2.47	97.96
8	tallest upper labial	1.26	99.22
9	internasal	0.58	99.80
10	loreal	0.20	100.00
11	premaxillary	0.00	100.00
12	jaw counter sunk	0.00	100.00